

How dangerous conservation ideas can develop through citation errors

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ABSTRACT

Incorrect or ambiguous citations can lead to ideas being distorted in subsequent publications via a process akin to Chinese Whispers, the process whereby a phrase or idea becomes distorted as it is passed from person to person. The propagation of incorrect ideas can have dangerous consequences for science as some ideas may be unfairly favoured because of the apparent supporting literature. Here we trace a specific example—the impacts of black rats *Rattus rattus* on Australian islands—and demonstrate how ambiguous or incorrect citations may lead to the development of distorted evidence for the mechanism behind rat impacts. This distortion has the potential to incorrectly influence conservation action, to overlook the need for further work or to induce action that is not necessarily justified. We highlight that authors, editors and publishers need to be vigilant with citation practices to ensure accuracy in reporting of scientific outcomes and we propose an approach to help ensure accuracy in citations.

Key words: Citation; unreliable; inaccurate; incorrect; publication; exotic; black rat; *Rattus rattus*; predator; extinction; dangerous.

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Introduction

Errors in citation are a serious issue for science. Plagiarism, the deliberate theft of someone else's intellectual property, is one form of citation error that arises when sources of ideas are not cited. Individuals that pass-off the ideas or work of others as their own and without acknowledgement via citation can suffer severe professional and even legal consequences (La Follette 1992), and such plagiarism is widely acknowledged as research misconduct. Yet there are other forms of citation errors, such as unreliable, inapplicable or misquoted citations that can also pose a serious threat to the quality of academic work and the development of scientific evidence. Citation bias or citation error is generally harder to detect than plagiarism and only recently it has begun to be acknowledged as a threat to academic integrity (e.g. Teixeira *et al.* 2013). In marine science, Todd *et al.* (2010) reported that one in four marine biology citations were in some way incorrect and should be viewed with caution. But how do such inaccuracies impact on science? In this paper we explore how incorrect citation may have dangerous consequences because an idea or result is referenced incorrectly, ambiguously or taken out of context, and propagated incorrectly in subsequent publications.

Following Todd *et al.*'s (2007) citation error classification, we propose several ways that incorrect citations can arise, including when authors:

- scan the literature to explore a specific topic of interest and interpret the ideas with a certain perspective that strays from the authors' intended interpretation;
- accurately reference the original text but omit key facts that can lead to an ambiguous interpretation of the idea by others (akin to Todd *et al.*'s (2007) "Ambiguous" category) - this form of error is hard to prevent because it depends on the interests of the reader;
- deliberately word a point or issue to give an inference that supports a flimsy hypothesis where such an inference is not justified;
- simply present an idea using the wrong citation (Todd *et al.*'s (2007) "No Support" category);
- pass a paper back and forth between collaborators, then editors and finally referees, with the result that ideas can get distorted through multiple edits;
- fail to consult primary source.

These errors can arise even more easily when there is a difference in the primary language used by the author and of the work being cited.

While the occasional citation error is arguably irrelevant, the problem is exacerbated when citation

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errors are compounded in a form of Chinese Whispers and incorrect information enters via subsequent publications. Chinese Whispers (also known as "Telephone" and "Gossip Game") is a game where a message is whispered between individuals many times and ultimately undergoes a significant change of meaning as errors arising during message transfer become magnified (OED 2014). For example, a global Chinese Whispers game held in 2012 resulted in the quote from Plato "Life must be lived as play", which began in a Melbourne library, turning into "He bites snails" 26 hours later in Alaska as it passed between 237 individuals and seven languages (Gossip 2012). Harzing (2002) revealed that such Chinese Whisper effects can also affect research via poor citation practices, leading to ideas that have no real support (see Todd and Ladle 2008a for examples). These incorrectly referenced ideas have the potential to then become further distorted in future publications and self-propagate as established fact.



Exotic black rats *Rattus rattus* in Australia: ferocious killers of mammals or simply misrepresented incorrect citation errors?". Photo by Malith Weerakoon.

Over time, scientific myth can become scientific legend and then very difficult to overturn. For instance, the assertion that Darwin's theory of evolution came from his study of Galápagos finches is one such legend. The fact that Darwin never studied Galápagos finches in close detail, nor even mentioned them in his *Origin of Species*, was revealed by Sulloway (1983), yet the legend of Darwin's Finches nevertheless lives on, and Darwin continues to be given credit for observations and insights of finches that he did not make (Marx and Bornmann 2013). Other studies have demonstrated how citation errors propagate through the literature and become established as fact: Wetterer (2006) exposed how poor citation practices led to the scientific community believing that exotic ants in Madeira were responsible for the extinction of native ants that never went extinct; likewise Harzing (2002) and Dufour and Carrol (2013) both examined and exposed how scientific myths propagate in the expatriate and medical literature respectively. In short, citation errors are a generic problem and future work has the potential to be incorrectly influenced (with possible dangerous consequences) by these inaccuracies.

In our paper, we use an Australian conservation example that focuses on the development of ideas behind the impacts of exotic black rat *Rattus rattus* predation on endemic wildlife on Australian islands and how these ideas might be exaggerated by multiple citation inaccuracies. Exaggerating the predation impacts of *R. rattus* may have dangerous consequences if wrong because it (i) may overshadow other ecological processes that may be occurring, such as disease transfer, competition, anthropogenic disturbance, habitat loss and so on, and (ii) potentially direct management authorities towards inappropriate conservation strategies.

Here, we describe the processes by which the citation errors might first occur and then propagate, leading to a significantly different understanding of the original idea. We then suggest three solutions to prevent inaccurate citations being compounded and dangerous ideas developing through this propagation process.

Case study: Are black rats really significant predators of Australian mammals?

Black rats are among the 100 worst alien species globally and are linked to many bird extinctions, through predation on eggs, chicks and adults, especially in island systems. But the key question is: are black rats predators of mammals and does this predation contribute to native mammal extinctions in Australia?

Our tracking of this story, and the potential role of Chinese Whispers in citation, begins with Burbidge and Manly (2002) who examined correlative patterns

between the presence of foxes, cats and rats and the occupancy and extinction of native mammals on offshore islands. Although they reported "*We were unable to find a significant correlation between the presence of rats and native mammal extinctions on Australian islands*", Burbidge and Manly (2002) nevertheless make inference about rats being predators of Australian mammals, first in their abstract and then throughout the paper by including rats with foxes and cats under the collective term "*exotic predators*". They provide no direct evidence that rats are indeed predators of any of the native mammals that they studied and this inference might have been the catalyst for the Chinese Whispers game to begin.

The listing of "*Predation by exotic rats on Australian offshore islands of less than 1000 km²*" as a Key Threatening Process (KTP 1999) under the *Environment Protection and Biodiversity Conservation Act* (1999), appears to make Todd *et al.*'s (2007) "No Support" mis-citation by stating that exotic rats are predators of native mammals. The listing states "*Exotic rats have also been implicated in the decline of a number of native mammals, lizards and insects through predation (Burbidge and Manly 2002; Cogger *et al.* 1993; Recher and Clark 1974)*". Out of the three citations, only the Burbidge and Manly (2002) one makes reference to rats and native mammals, and more importantly, Burbidge and Manly (2002) found a non-significant association between black rats and declining native mammals, which does not necessarily imply predation. Yet readers of the KTP listing who are interested in exotic rat impacts on native Australian mammals would get the incorrect impression that research has found rat predation causing mammal declines. This represents one way the Chinese Whispers process might have been continued.

Morris (2002) reported that burrowing bettongs *Bettongia lesueur* were unintentionally exterminated from Boodie Island in Western Australia during a bout of *R. rattus* poisoning in 1985. Fortunately, the *B. lesueur* population recovered successfully but only after a reintroduction program in 1993, as Morris (2002) clearly states in his abstract: "*While the rats were eradicated [from Boodie Island], the bettongs also disappeared. They have since been successfully re-introduced and their abundance is well above pre-baiting levels*". Although the increases in bettong numbers might have been due to relaxed predation pressure from rats, there was no control island used in this "experiment" and it remains plausible that bettong increases had little to do with rat numbers. Morris (2002), however, infers predation might be at play by incorrectly citing Burbidge and Manly (2002) "*Burbidge *et al.* (1997) did not find a relationship between the presence of rats and mammal extinctions; however, a more recent analysis (Burbidge and Manly 2002) does support such a link*". Again a mis-citation leads to the impression that rat predation is a factor in bettong ecology, creating circumstantial evidence for rats as predators of mammals as large as bettongs.

Indeed, Mulder *et al.* (2009) might have been influenced by the inference in Burbidge and Manly (2002) when they note in their introduction "*Humans have introduced rats (*Rattus* spp.; Rodentia: Muridae) to islands across the globe, suppressing or eliminating populations of native seabirds ..., and mammals (e.g. Burbidge and Manly 2002) as a result of predation by rats*". This is another mis-citation and another "Whisper" with rats being now linked to suppressing populations of native mammals. Zewe *et al.* (2013) also mis-cite Burbidge and Manly (2002) in a very similar way "*Invasive rodents have been implicated in the decline and extinction of insular seabirds (Atkinson 1985; Towns *et al.* 2006; Jones *et al.* 2008; Banks and Hughes 2012) and mammals (Burbidge *et al.* 1997; Burbidge 1999; Burbidge and Manly 2002; Harris 2009; Banks and Hughes 2012).*"

Ambiguous citations of Burbidge and Manly (2002) and Morris (2002) might have also contributed to the Whispers process. Towns and Atkinson (2006) ambiguously cite Morris (2002) by reporting "*post-eradication spread and up to 10-fold increase*" of the *B. lesueur* population. Banks and Hughes (2012) also cite Morris (2002), this time in the context of potential competitive processes and described that *B. lesueur*'s range expanded (the population was "*no longer restricted to the limestone areas of Boodie Island*" (Morris 2002) following exotic rodent eradication. Although in both cases the citation is correct, neither Towns and Atkinson (2006) nor Banks and Hughes (2012) make explicit mention of the reintroduction process (c.f. Todd *et al.*'s (2007) "Ambiguous citation" category). Later authors attempting to understand rat impacts by interpreting the results of Morris (2002) solely via Towns and Atkinson (2006) or Banks and Hughes (2012) could easily make the wrong interpretation and make another step in the Chinese Whispers process.

Most recently, Hanna and Cardillo (2014) examined the impacts of *R. rattus* on islands. They identify a link between *R. rattus* presence and native mammal extinctions and conclude that predation by *R. rattus* is the driving mechanism, and they discount other potential mechanisms such as competition and disease transfer. As with previous authors, they ambiguously cite Morris (2002) saying that "*After black rat eradication on Boodie and Middle islands, Western Australia, the number of burrowing bettongs (*Bettongia lesueur*) and golden bandicoots (*Isodon auratus*), respectively, rose considerably (Morris 2002)*", but they also fail to mention the translocation procedure as part of the population recovery of the bettongs. It is possible that the series of six papers containing mis-citations or ambiguous citations of the original idea (as listed above) may have contributed to this concept (black rats as predators of native mammals on Australian Islands) becoming established in the literature. The danger, however, is that these papers can now be used to support studies that propose rats as the driving force

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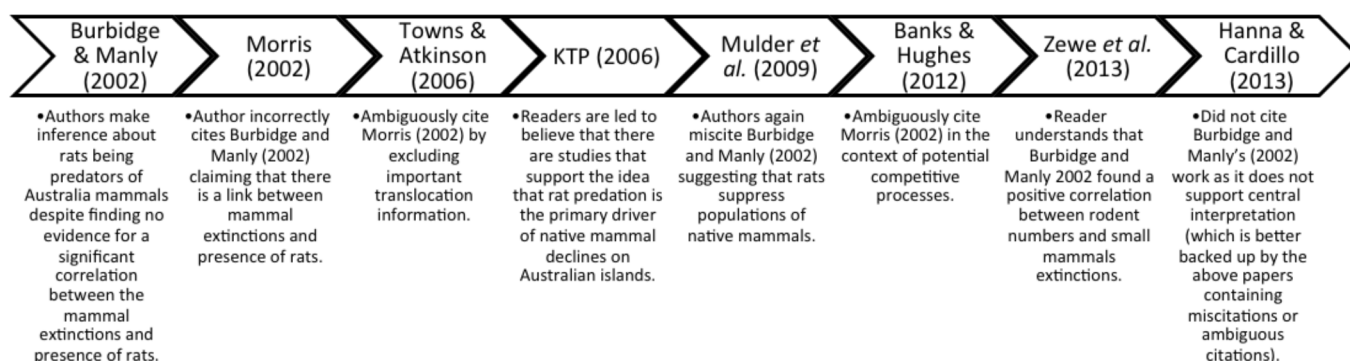


Figure 1. Timeline of citation error events in the idea that introduced black rats *Rattus rattus* are predators of Australian native mammals.

for mammals extinctions of species up to and even greater than 2.7 kg (e.g. Hanna and Cardillo 2014).

If the idea that *R. rattus* might drive mammal extinctions is incorrect, the specific role of predation as the causal mechanism is a potentially dangerous one as it may induce an inappropriate conservation solution when in reality other mechanisms are at play. For example, the listing of predation by *R. rattus* on offshore islands as a key threatening process necessitates actions to prevent such predation impacts, such as rodent population control, but this action may not be effective where, for example, the real agent of decline is disease (e.g. Wyatt *et al.* 2008). Hanna and Cardillo (2014) suggest further "Given that black rats are a major threat to native mammals, the eradication of cats, foxes or dingoes from islands could result in considerable loss of island mammal biodiversity through the release of rat populations". The media interpreted this as a suggestion that feral cats are protecting native mammals ("Feral cats help some endangered mammals survive, report says" Popkin 2013). But does this suggestion hold if rats are not in fact the meso-predators they are assumed to be, and that their impact on native mammals is in fact driven by other ecological processes? It is noteworthy that none of the studies mentioned above stating that rats are predators of Australian mammals provides any empirical or experimental evidence to support this assertion (Smith and Banks *In press*). The timeline of the Chinese Whispers of the citation errors is shown in Figure 1.

Discussion

While plagiarism of academic ideas by researchers is admonished by academic institutions and society at large, the consequences of incorrect citation practices are rarely addressed. Whether or not these errors are simply due to ambiguous or incorrect citation practices, we argue that incorrect ideas can emerge through a process of Chinese Whispers (see also Harzing 2002). With time, these incorrect or incomplete ideas have the potential to become dogma, especially when they reinforce already entrenched thinking. Dogma is especially dangerous as it has the potential to stagnate

the progress of science and our understanding of the natural world and solutions to management problems (Allen *et al.* 2011). In addition, key ideas have the potential to be unfairly promoted while other authors are not properly credited for their work.

In recent years, the field of medical research has called for tightening of citation practices with many papers stressing the importance of scientific rigour and integrity (Al-Benna *et al.* 2009; Davids *et al.* 2010; Lukić *et al.* 2004; Reddy *et al.* 2008). Some other scientific disciplines have begun to acknowledge this problem and suggest improvements to their practices (Hausmann *et al.* 2013; Todd *et al.* 2010; Todd and Ladle 2008a; Todd and Ladle 2008b; Todd *et al.* 2007), yet we still believe that there is a need for a set of practical guidelines for citation practices. Harzing (2002) proposed 12 guidelines for good citation practice, which would help avoid the Chinese Whispers effect. Based on these, we put forward the following three actions by the key stakeholders at each stage of the publication process.

- Authors must always refer back to primary sources to ensure that a citation is correct for how they want to use it;
- Reviewers must examine and highlight any potential ambiguity in wording (either deliberate or accidental);
- Editors must be vigilant for correct citation of works in more obscure places, like books, foreign language sources or older publications.

Todd and Ladle (2008a) suggest further that journals might consider undertaking random audits of papers to check citation accuracy.

Lastly, technology and, in particular, internet access, has likely played an important role in changing citation practices in science. Through online books and journals, authors now have access to more resources than ever before, and there is a decline in the use of hard copy journals as researchers (and libraries) opt for online-only access. With all this extra information, it is possible

that the quality of citations has decreased since authors are expected to cite as much and as broadly as possible (since it is available). Also, now authors can quickly run electronic keyword searches to pick out certain key ideas that are not necessarily central to the article, something that is arguably less likely to happen with hard copies that had to be read. Many authors may only have access to the abstracts of some papers that are otherwise locked behind expensive paywalls. Abstracts, however, lack the detail and context of the full manuscript and rarely contain citations, which create opportunities for incorrect ideas to perpetuate if abstracts are taken as gospel.

Interestingly, ecologists rarely use direct quotes from other published papers in their text (c.f. the humanities), but instead re-phrase the findings of other scientists and add the citation. This means

that the reader must go back to the original text and search for the correct part in the text to confirm that the citation is correct. This creates considerable additional reading time, which is perhaps one reason why the Chinese Whispers process emerges when an author makes ambiguous citations. One solution (that is quite feasible with current technology) would be for authors to nominate the specific location of an idea or result for each citation. This location could then easily be hyperlinked into the final journal PDF, allowing readers to run the mouse over the reference to reveal the author and the quote in the original article. Many journals already do this by linking references to the location in the citing article, but we suggest linking back to the idea in the original work. While this would not work for all citations, it has the potential to reduce the risks of incorrect and ambiguous citation.

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